	Type	Hits	Search Text	DBs	Time Stamp
1	BRS	277	438/612,613.ccls. and (opening or recess or hole) and pad and bump	USPAT; US-PGPUB	2002/11/20 15:41
2	BRS	221	(438/612,613.ccls. and (opening or recess or hole) and pad and bump) and (etching or removing)	USPAT; US-PGPUB	2002/11/20 15:42
3	BRS	170	((438/612,613.ccls. and (opening or recess or hole) and pad and bump) and (etching or removing)) and @ad<=20010215	USPAT; US-PGPUB	2002/11/20 16:48
4	BRS	121	438/614.ccls. and (opening or recess or hole) and pad and bump	USPAT; US-PGPUB	2002/11/20 15:42
5	BRS	104	(438/614.ccls. and (opening or recess or hole) and pad and bump) and (etching or removing)	USPAT; US-PGPUB	2002/11/20 15:42
6	BRS	91	((438/614.ccls. and (opening or recess or hole) and pad and bump) and (etching or removing)) and @ad<=20010215	USPAT; US-PGPUB	2002/11/20 15:42
7	BRS	46	(((438/614.ccls. and (opening or recess or hole) and pad and bump) and (etching or removing)) and @ad<=20010215) not (((438/612,613.ccls. and (opening or recess or hole) and pad and bump) and (etching or removing)) and @ad<=20010215)	USPAT; US-PGPUB	2002/11/20 15:42

L Number	Hits	Search Text	DB	Time stamp
1	227	((257/736-738.ccls. and (opening or recess or hole) and pad and bump) and (etching or removing)) and @ad<=20010215	USPAT; US-PGPUB	2002/11/20 16:51
2	1		USPAT	2002/11/20 17:09
3	1		USPAT	2002/11/20 17:10
4	1		USPAT	2002/11/20 17:10
5	1		USPAT	2002/11/20 17:11
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TITLE: Method for making bumps

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A **bump** is formed on a semiconductor wafer which has a **pad** electrode thereon. The method includes the steps for coating a first organic film on a semiconductor water; drying the first organic film; applying an excimer laser to a portion of the first organic film substantially corresponding to the **pad** electrode to thereby form a first opening in the organic film; forming at least one metallic film on the first organic film and the opening; coating a second organic film on the metallic film; drying the second organic film; applying an excimer laser to a portion of the second organic film substantially corresponding to the first opening to thereby form a second opening in the second organic film; and providing and melting solder at the second opening to form a solder **bump**. Since the openings of the organic films are formed by the excimer laser, the openings can be formed in a short time with high accuracy. Thus, the **bump** with high quality can be formed at a low cost.

The present invention relates to a method for forming a **bump on a pad** electrode of a semiconductor device. More specifically, the present invention relates to a method for forming a **bump**, which can remove a portion of an organic film by using an excimer laser and thereby form an opening.

Conventional methods for forming a **bump on a pad** electrode of a semiconductor device include a metal evaporation method, an electroplating method, a

stud-bumping method, an adhesive applying method, etc. However, these methods for forming a **bump** may destroy a passivation film because the passivation film is suffered with an excessive force by covering pinholes on the passivation film of the semiconductor wafer and by deformation of the **bump** with an unbalanced force. Thus, in order to prevent the destruction of the passivation film, a polyimide film has been used.

In addition, a photoresist for plating is used in forming a **bump** by using the electroplating method. FIG. 7 shows a process chart of a conventional method for forming a **bump**. The conventional method is the electroplating method using the polyimide film and the photoresist film for plating. In the illustrated process, a photo-insensitive polyimide is used. FIGS. 8(a)-8(j) show cross-sectional views of a **pad** electrode portion of a semiconductor wafer in the major steps shown in FIG. 7.

The conventional method for forming a **bump** using an electroplating method will be described with reference to these figures.

Next, a photoresist for **etching**(RS) is coated on the polyimide film 10 and thereby a photoresist film for **etching** 15 is formed (S5) as shown in FIG. 8(c). Then, common steps of the electroplating method, such as pre-baking step(S6), exposure step(S7) and developing step(S8) of the photoresist film, are carried out. Consequently, the portion of the photoresist film for **etching** 15 is removed as shown in FIG. 8(d) and an opening 16 is formed.

Next, post-baking step (S9) of the photoresist film for **etching** 15 is carried out, whereby the photoresist film 15 is dried. Thereafter, an exposed portion of the polyimide film 10 at the opening 16 of the photoresist film for plating is removed by using hydrazine in the **etching** process(S10), whereby an opening 11 of the polyimide as shown in FIG. 8(e) is formed. Thereafter, the photoresist film 15 is exposed with an ultra visible light, etc., whereby the photoresist film 15 is removed by a resist **removing** agent (S11). Thereafter, aluminum, chrome and copper is deposited onto the polyimide film 10 and the

opening 11 of the polyimide by vacuum evaporation, whereby an under **bump** metallurgy(UBM) 4 for the **bump** is formed (S12) as shown in FIG. 8(f). The under **bump** metallurgy 4 also has the function of the common electrode of electroplating.

Next, a photoresist is coated on the under **bump** metallurgy 4, whereby a photoresist film for plating 20 is formed (S13) as shown in FIG. 8(g). Then, pre-baking step(S14), exposure step(S15) and developing step(S16) of the photoresist for plating 20 are carried out. Consequently, the portion of the photoresist for plating 20 is removed as shown in FIG. 8(h), whereby an opening 21 of the photoresist for plating is formed. Then, post-baking step of the photoresist for plating 20 is carried out (S17).

Next, the above processed semiconductor wafer is attached to a plating unit (no illustration) (S18), then plating of copper 30 (S19) and plating of solder 40 (S20) are carried out with pre-determined thickness respectively. Thereafter, the photoresist for plating 20 is removed by a resist **removing** agent (S21) and the unnecessary under **bump** metallurgy 4 is removed by **etching** with a solder 40 as an **etching** mask (S22). Thereafter, a flux is applied on plated solder 40 (S23), and then the solder 40 is melted in a reflow furnace under a nitrogen atmosphere, whereby a spherical shaped solder **bump** 41 is obtained as shown in FIG. 8(j). Thereafter, an inspection is carried out and a process for forming a solder **bump** 41 is completed.

However, this method for forming a solder **bump** by using an electroplating method has the problems as follows.

First, after the post-baking step of the polyimide, the residue (scum) of polyimide (i.e. ultra thin film) is left on the aluminum electrode in the periphery of the opening 11 of the polyimide film. The residue of polyimide can not be removed in the developing step. As a result, the opening 11 of the polyimide with a predetermined size can not be obtained and the quality of the **bump** becomes worse. Especially, when the size of the opening 11 of the

polyimide is 40 .mu.m or less, the residue of polyimide can not be ignored and thereby a plasma dry **etching** is needed in order to remove the residue of polyimide.

Second, six steps for forming the opening 11 of the polyimide, such as the photoresist coating step (S5) through the photoresist post-baking step (S9) and the photoresist **removing** step, and two steps for forming the opening 21 of the photoresist for plating, such as, the photoresist for plating pre-baking step (S14) and the photoresist for plating exposure step, are necessary and therefore it takes a long time to complete the process.

The object of the present invention is to provide a method for forming a **bump** capable for **removing** an organic film and thereby forming an opening with high accuracy in a simple process.

The present invention provides a method for forming a **bump** on a semiconductor wafer which has a **pad** electrode thereon, comprising;

and a step for forming an **opening by removing** a portion of the organic film substantially corresponding to the **pad** electrode, with an excimer laser. Then, solder is applied to the opening and is then melted to form a solder **bump**.

The present invention also provides a method for forming a **bump** on a semiconductor wafer which has a **pad** electrode thereon, comprising;

a step for drying the first organic film; a step for forming an **opening by removing** a portion of the first organic film substantially corresponding to the **pad** electrode, with an excimer laser,

and a step for forming the second **opening by removing** a portion of the second organic film substantially corresponding to the opening, with an excimer laser. Then, solder is applied to the second opening and is then melted to form a solder **bump**.

FIG. 1 shows a process chart of the method for forming a **bump** of Embodiment 1.

FIG. 2(a) through (h) show cross sectional views of **bump** forming portions of the major steps in FIG. 1.

FIG. 3 shows a process chart of the method for forming a **bump** of Embodiment 2.

FIG. 4(a) through (g) show cross sectional views of **bump** forming portions of the major steps in FIG. 3.

FIG. 5 shows a process chart of the method for forming a **bump** of Embodiment 4.

FIG. 6(a) through (c) show cross sectional views of **bump** forming portions of the main steps in FIG. 5.

FIG. 7 shows a process chart of the conventional method for forming a **bump** and FIG. 8(a) through (j) show cross sectional views of **bump** forming portions of the major steps in FIG. 7.

The method for forming a **bump** of Embodiment 1 is described with reference to FIG. 1 and FIGS. 2(a)-2(h).

In the washing step (S101), the semiconductor having a passivation film 2 and an aluminum electrode 3 thereon as shown in FIG. 2(a) is washed in order to form a **bump** thereafter.

In the polyimide coating step (S102), a polyimide film 10 is formed by using spinner as shown in FIG. 2(b) which has the functions of a cushion against a force applied to a **bump** and for covering pinholes in the passivation film 2. Thereafter, in the polyimide post-baking step (S103), a heat treatment at 350.degree. C. for 30 min. is carried out in order to obtain the completely cured polyimide film 10. Consequently, a whole surface of the semiconductor

device is covered with the polyimide film 10 as shown in FIG. 2(b).

The steps S101 through S103 are the same as those corresponding to the steps of the conventional method for forming a **bump** as shown in FIG. 7 and FIGS. 8(a) and 8(b).

On the completed semiconductor wafer, polyimide PIX-1400 (HITACHI KASEI KOUGYOU Co. LTD) is coated as a polyimide resin with 2.0 .mu.m in thickness, and the polyimide film is dried and post-baked. Thereafter, the opening 11 of the polyimide film, which has 100.times.100 .mu.m.sup.2 in area, is formed inside of a **recess** portion 3', which corresponds to the aluminum electrode 3. As the excimer laser beam, 30 pulses of KrF excimer laser beam (wave length:248 nm) of 0.23 J/cm.sup.2 energy density are employed. Consequently, there is no degradation on the portion of the aluminum electrode 3 of about 1.0 .mu.m thickness where the polyimide film is removed.

After the polyimide opening forming step (S104), in the step for forming the under **bump** metallurgy (S105), aluminum, chrome and copper are deposited by using a vacuum evaporation method and thereby a the under **bump** metallurgy 4 of the **bump** is formed as shown in FIG. 2(d). The under **bump** metallurgy 4 also has the function as a common electrode of electrolyte plating.

Next, in the photoresist coating step (S106), as shown in FIG. 2(e), a photoresist for plating(PR), which has the function as a mask of the electrolyte plating, is coated by using a spinner. Thereafter, in the post-baking step (S107) of the photoresist for plating(PR), a heat treatment at 140.degree. C. for 30 min. is carried out in order to protect from a plating solution. The steps S105 through S107 are the same as those corresponding steps of the conventional method for forming a **bump**.

In the following, an example for forming the opening 21 of the photoresist film for plating 20 by using an excimer laser beam 50 will be described. On the under **bump** metallurgy 4, OMR-83 (TOKYO OHKA KOUGYOU Co, LTD.) is coated as a

photoresist film for plating 20 with 3.5 .mu.m in thickness, dried and post-baked. Thereafter, the opening 21 of the photoresist for plating, which is 150.times.150 g m.sup.2 in area, is formed in a portion substantially corresponding to the **recess** portion 4' of the under **bump** metallurgy 4. As the excimer laser beam, 20 pulses of KrF excimer laser beam (wave length:248 nm) of 0.425 J/cm.sup.2 energy density, are employed. Consequently, there is no degradation on the portion of the under **bump** metallurgy 4 of about 1.0 .mu.m thickness where the photoresist film for plating 20 is removed.

As for the following steps, such as the attaching to plating equipment step (S109) through the inspection step (S115), the steps corresponding to the conventional method for forming a **bump** can be carried out in the same manners.

First, according to the present method for forming a **bump**, it is possible to eliminate the quality deterioration of the **bump** by controlling the excimer laser power in the appropriate level in the **etching** step and by **removing** of the residue of polyimide, which is left in the periphery of the opening of polyimide on the aluminum electrode after the post-baking step, and which can not be taken off by the conventional photolithography technique.

Third, due to the first and second advantages, it is possible to provide the method for forming a **bump** wherein the process cost is cheap and the total steps(time) is short.

According to Embodiment 2, an under **bump** metallurgy is formed by electroless plating method and a solder **bump** is formed by an adhesive applying method.

Next, in the forming step of the under **bump** metallurgy (S205), 2 .mu.m of a nickel film 5 is plated by the electroless plating method on the aluminum electrode 3 through the polyimide(PI) opening 11 as shown in FIG. 4(d). Thereafter, in the adhesive application step(S206), an adhesive layer 6 is formed on the nickel film 5 selectively as shown in FIG. 4(e). Thereafter, in solder ball attachment step (S207), solder balls 42 are scattered onto the

semiconductor wafer and thereby a solder grain 42 is adhered only to the adhesive layer 6 as shown in FIG. 2(f). Thereafter, the solder reflow step (S208) and the inspection step (S209), which are the same as those of the Embodiment 1(S114.about.115), is carried out and thereby a solder **bump** 43 is formed.

According to this embodiment 2, a further advantage such that a step for forming a **bump** becomes simpler, can be obtained.

According to the Embodiment 3, the polyimide coating step (S102) through the polyimide opening forming step (S104) are omitted from the steps described in the Embodiment 1 and other steps are remained. An under **bump** metallurgy 4 is formed directly on the passivation film 2 in the same manner as disclosed in the Embodiment 2. Further, the photoresist film for plating is removed by irradiating an excimer laser beam 50 in the same manner as disclosed in the Embodiment 2 and thereby an opening 21 of the photoresist film for plating is formed.

According to this embodiment, in the gold plating step (S411), a surface of the plated copper 30 is further plated with gold 60. Thereafter, in the first resist removal step (S412), the photoresist film for plating 20 is exposed with the excimer laser beam as shown in FIG. 6(a) and thereby a portion of the photoresist film for plating, where gold is not plated, is removed as shown in FIG. 6(b). Thereafter, in the **etching** step of the under **bump** metallurgy (S413), the metallurgy 4 is etched by using gold 60 and the photoresist film 20 under copper 30 and gold 60 as a mask.

Next, in the second resist removal step (S414), the photoresist film for plating 20 under the copper 30 and gold 60 is removed by using a resist **removing** agent as shown in FIG. 6(c). Thereafter, in the inspection step, an inspection is carried out.

According to the Embodiment 4, since an **etching** of the under **bump** metallurgy 4

is not made under the **bump** by the presence of the photoresist film 20 for plating just under copper 30, gold 60 and the **etching** control is easy. In addition, since good uniformity of the **etching** can be obtained, the **etching** margin becomes smaller and bumps with higher density can be obtained.

1. A method for forming a **bump** on a semiconductor wafer which has a **pad** electrode thereon, comprising;

a step for applying an excimer laser to a portion of said organic film substantially corresponding to a **pad** electrode on the semiconductor wafer to thereby form an opening in the organic film; and

a step of providing and melting solder at the opening to form a solder **bump**.

4. The method according to claim 3, wherein said photoresist film for plating is removed by using the excimer laser after the **bump** is formed on the **pad** electrode.

5. A method for forming a **bump** on a semiconductor wafer which has a **pad** electrode thereon, comprising;

a step for applying an excimer laser to a portion of said first organic film substantially corresponding to the **pad** electrode to thereby form a first opening in the organic film;

a step of providing and melting solder at the second opening to form a solder **bump**.

7. The method according to claim 5, wherein said resist film for plating is removed by using the excimer laser after the **bump** is formed on the **pad** electrode.